Road Safety Analysis Using Multi Criteria Approach For Rural Road In Nashik Dist.

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***Abstract*: We know, Road accidents are major problem in transportation sector all over India. The safety assessments of rural road have a big share in the transportation sector and majority of fatal accidents usually occur on such road project. Mainly focus of this is on PRADHAN MANTRI GRAM SADAK YOJANA which is mostly used in rural area. Site visit and collection of information were performed from well experienced engineers as well as contractors of PMGSY scheme. The present papers is on attempt that aims that the analysis of major safety factors affecting on safety of PMGSY road. For analysis of this study questionary survey was conducted and three method of MCDM was applied to study the interaction and relation of one factor over another. The results of this study described that the depending upon the PMGSY engineers and contractor's feedback. We can decide safety impact factor that affect safety assessment of PMGSY road from this engineers point of view in nashik district.**

***Keywords:* Road Safety, safety impact factor; RII, AHP, Multi Criteria Decision making.**

I. INTRODUCTION

Road accident is a big problem which accounts huge loss of lives and cost to a country. They claim a child every three minutes and 3000 lives every day, which has increased safety awareness all over country. To enhance road safety, the united nation has declared the decade of 2011-2020 as the road safety decade thus increasing the importance of Road safety Analysis (RSA). This is a preventive measure to identify potential safety problems for all road users and to ensure that measures to eliminate or to reduce the problems are considered fully.

India has large road network in the world with a rapid increase in the construction of highways and rural road now a days. Rural road is very important part which is mostly effect on economic growth of the country. Various road development programmes has been introduced, such as the Golden Quadrilateral, East-West and North-South corridors. For rural road connectivity, the Pradhan Mantri Gram Sadak Yojana (PMGSY), a fully centrally sponsored programme, was initiated by the government of India to provide all weather road connectivity in rural areas of the country. It was launched in 2000 with an objective to provide connectivity to all habitation with 500 persons in plain areas and 250 and above in hilly states, tribal and desert areas. Safety of rural areas towards accidents and casualties is lower than urban areas. It is observed that according to 2011 statistics, it has been found that accidents and causalities in rural areas account for 53.5% and 63.4% respectively. However the statistics for urban areas are 46.5% and 36.6% due to better road, better protection and faster medical facilities. Detailed statistics record of accidents in rural roads are not easily available because quite often they are not recorded and they have not awareness for road saety. In the recent times, the concept of road safety Audit, which is formal safety performance examination of an existing or future road or intersection by an independent, multidisciplinary term for improvements in safety of all road users has been introduced in construction of PMGSY roads which are funded by the World Bank and Asian development Bank.

1.2 Need of study

Infrastructure is the important part of the economy. Road infrastructure plays a very important role for development, in this case road safety is very important.

1.3 Objective of Project

1. To determine the Priority of the safety requirement of a certain category of rural road.
2. To increase awareness for PMGSY road Safety in rural area.
3. To determine the quantify level of safety of road under PMGSY.
4. To study the detail concept of Road safety analysis (RSA)

II. DATA COLLECTION

2.1 Case Studies

Case study for this project, I have select four old road of PMGSY in Kalwan taluka, nashik district. The road has same length and topographic condition. General details of Road selected are tabulated as shown below.

Table no 1: Details of case study.

Particulars	Road 1	Road 2	Road 3	Road 4
Name of Road	Ambevani to Talegaon vani.	SH-18 to Sadadvihir	T-09 to Mahal-village Road	SH-22 to Khadki- village road.
Location	Near vani gaon	Nanduri gaon	Near Kanashi town.	Kanashi to Jaydar village road.
Taluka	Dindori	Kalwan	Kalwan	Kalwan
Year of completion	2010-2011	2011-2012	2012-2013	2010-2011
Length of Road	6 KM	7 KM	9 KM	10.44
Cost of Road	175 Lakh	191.86 Lakh	497.31 Lakh	592.87

2.2 Accidents Record of case study

This data has collected from local information given by local people and from police station at the place where case study has been selected in Kalwan taluka, Dist- Nashik. For this case study I have selected four PMGSY road having same length and topography and they were complete at same time.

Table no 2: Accidents Record of case study.

Year	Total Accidents.
2013	42
2014	28
2015	18
2016	23
2017	22

Table no 3: Causes of accidents as per criteria of road.

Road characteristics	2013	2014	2015	2016	2017
Sight Distance	5	3	2	3	2
Sharp Curves	4		2	3	2
Super Elevation	3				2
Severity of roadside environment	7	4	1	2	1
Drainage provision			1	2	
Shoulder Width		3		2	3
Shoulder Drop					2
Quality of shoulder					1
Pavement Edge Failure	6	4	2	1	
Pothole			2	1	2
Reveling and Spelling					
Cracking	2	3	1	2	1
Rutting					
Direct access from houses to roads	7	5	3	2	2
Sing and Marking			**2**	**2**	
Blind turn on road	8	6	2	2	2

According to this data it is observed that most of accidents is happened by this criteria.

- Sight Distance
- Sharp Curves
- Severity of roadside environment
- Shoulder Width
- Pavement Edge Failure
- Cracking
- Direct access from houses to roads
- Blind turn on road

Table no 4. Information of road regarding road safety criteria as below.

As per the design standards of rural roads given by IRC guidelines shown in Table, ratings for criteria viz., sight distance, sharp curves, super elevation and shoulder width have been taken. However, severity level ratings for the parameters-shoulder drop, pavement edge failure, pothole, raveling and spelling, cracking and rutting were not available in the Indian standards and thus have been adopted from FHWA guidelines

Sight Distance	>90m (good)	=90m(medium)	<90m(poor)
Sharp Curves	> 90° – (Good)	90° – (Satisfactory)	< 90° - (Poor)
Super Elevation	< 7 percent (as per design) – (Good)	7 percent – (Satisfactory)	> 7 percent – (Poor)
Severity of roadside environment	< 10m – (Good)	(10-100)m – (Satisfactory)	>100m – (Poor)
Drainage provision	high	medium	low
Shoulder Width	>1.875m – (High)	1.875m – (Medium)	<1.875m – (low)
Shoulder Drop	0.25-0.5" (low)	0.5-1"(Medium)	>1" (High)
Quality of shoulder	Good	satisfactory	poor
Pavement Edge Failure	<1%(low)	1-2%(medium)	>2%(high)
Pothole	<1"depth (low)	Potholes>2"deep and cover<1sqft area (Medium)	Potholes>2"deep and cover>1sqft area (high)
Reveling and Spelling	Aggregate and/or binder has started to wear away (low)	Aggregate and/or binder has worn away, moderately pitted surface (Medium)	Aggregate and/or binder has worn away, severely pitted surface (high
Cracking	Mean width of spall (crack) < 0.635cm	Mean width of spall (crack) > 0.635cm	Severe spelling
Rutting	0.25-0.5" (low)	0.5-1"(Medium)	>1" (High)
Direct access from houses to roads	1-3 no of houses	3-7 no of houses	>7 no of houses
Sing and Marking	Good	Medium	Poor
Delineation	High	Medium	Low
Blind turn on road	1-3 no of turns	3-7 no of turns	>7 of turns

Table no 5: of Road measurement as per criteria.

Road characteristics	Road 1	Road 2	Road 3	Road 4
Sight Distance	< 90M	< 90M	< 90M	=90M
Sharp Curves	<90°	<90°	=90°	=90°
Super Elevation	7 percent	7 percent	<7 percent	<7 percent
Severity of roadside environment	>100M	>100M	>100M	>100M
Drainage provision	Low	Low	Low	Medium
Shoulder Width	0.5 - 0.7 M	0.5 – 0.6 M	1 – 1.2 M	1.3 – 1.6 M
Shoulder Drop	0.6''	0.5''	0.8''	0.2''
Quality of shoulder	Poor	Poor	Satisfactory	Satisfactory
Pavement Edge Failure	1.2%	>2%	1.2%	<1%
Pothole	>2'', 1-2 sqft Area	>2'', 2-3 Sqft Area	<1"	<1"
Revelling and Spelling	Medium	High	Medium	Low
Cracking	0.5-1 CM	0.5-1CM	1-1.5 CM	1-.5 CM
Rutting	0.7-1''	0.8-1''	0.5-0.8''	0.5-0.7''
Direct access from houses to roads	7 No	14 No	23 No	9 No
Sing and Marking	Low	Low	Low	Medium
Blind turn on road	6 no	4 no	9 no	11 no

III.METHEDOLOGY

In this project methodology include general introduction and objectives, scope of project. Then literature study about road safety analysis. For understand the whole concept of RSA using various method, the first method is used for analysis is Relative Importance Index (RII). By this method we had gave ranking to alternatives by priorities them. Then another important method used is Analytic Hierarchy Process.

1. Relative important index

For this analysis the questionnaire survey was done by field experts and PMGSY engineer. The questionnaire had designed so that respondents can give the rank to their opinions. For analysis of this data RII method is used. RII is calculated for each of the indicators and ranked accordingly.

$$RII = \frac{\sum W}{A \times N}$$

Here
W = Weighting given to each factor by the respondents (ranging from 1 to 5, where 1= no impacts, 2= negligible impact, 3=marginal impact, 4= moderate impact, 5= major impact),
A = Highest weightage given for that factor,
N = Total Number of respondents.

Table No.6 Analysis of Ranking of Factors.

FACTORS	RII	RANK
sight distance	0.9641	1
Sharp curve	0.9641	2
super elevation	0.8051	11
sevarity of road side env	0.759	13
drinage provision	0.7179	15
shoulder width	0.8051	10
shoulder drop	0.8205	8
quality of shoulder	0.7333	14
pavement edge failure	0.8513	5
pothole	0.8462	6
reveling and spelling	0.6564	17
cracking	0.641	18
Rutting	0.6051	19
Direct Access from house	0.9026	4
Traffic volume	0.8051	9
Sign and marking	0.8205	7
Blind turn	0.9231	3
Specific width	0.7692	12
Road side env	0.6667	16

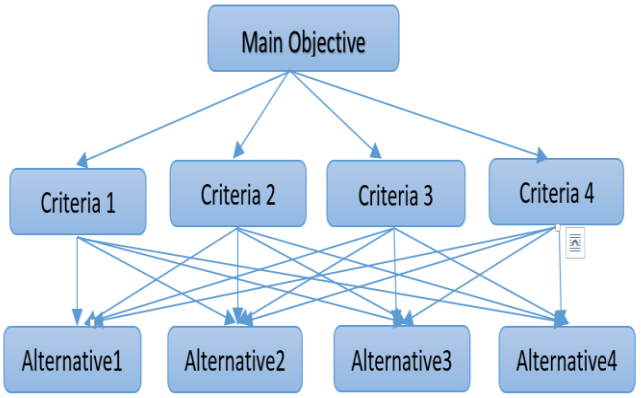
2. Analytic hierarchy process.

The AHP technique is used in this project for find complex decision in road safety criteria. This is the structure technique for finding and analyzing complex decision, based on mathematics and psychology. It was developed in 1970 by Thomas L Saaty. . Essentially, the AHP works by developing priorities for alternatives and criteria and is used to judge the alternatives. Initially, priorities are derived for the criteria in terms of their importance to achieve the goal

Table No. 7 Saaty scale used in AHP

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2 3	Weak or Slight Moderate Importance	Experience and judgment slightly favour one activity over another
4 5	Moderate plus Strong Importance	Experience and judgment slightly favour one activity over another
6 7	Strong plus Very strong or demonstrated importance	An activity is favored very strongly over another, it's dominate demonstrated in practice.
8	Very, very strong Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation

Fig. 1 AHP hierarchy of objectives, criteria and alternatives



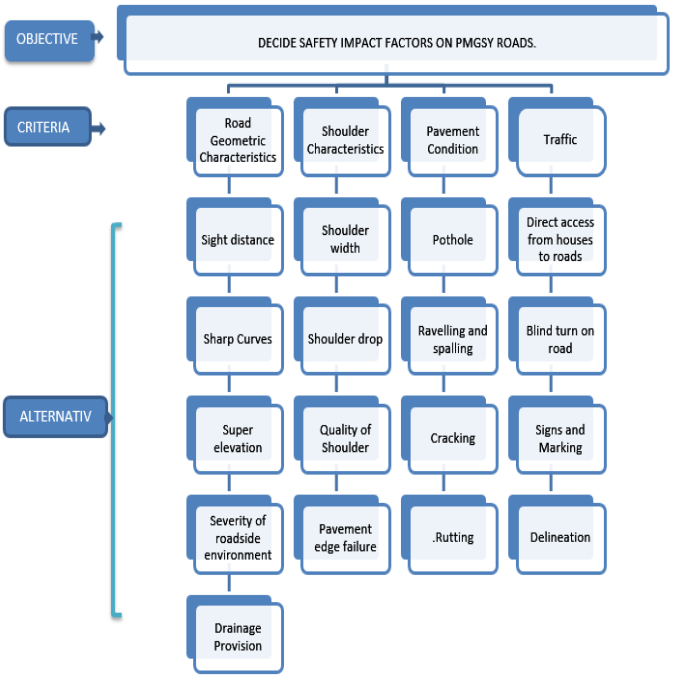
Introduction.

The questionnaire interview had carried out with number of contractors of PMGSY, and PMGSY engineers, road field experts' which are located in the Nashik region of Maharashtra (India). The interviews were carried out among top-level engineers who have an experience more than 10 to 12 years. Because they have sufficient knowledge about the safety importance, working site conditions and safety criteria. The 39 interviews took place over a 3 month period between December 2017 to January 2018 and each lasted approximately half to one hours. The questionnaire was carried through face-to-face interviews and it consisted of questionnaire format including different AHP tables.

a) Application Analytic Hierarchy Process:

The AHP methodology is applied in Kalwan taluka of Nashik Dist. Decides safety impact factors that affect safety assessment of rural road among the number of alternative available in Nashik. Therefore an example is considered for deciding the safety impact factors that affect safety assessment of road among four factors, selection attributes were identified and these are RGC- Road Geometric Characteristics, SC- Shoulder Characteristics, PC- Pavement Condition, and TRF-traffic.

Fig. 2: The hierarchy of the criteria and the alternatives



1. Determining Weights of Main Criteria (Level 1)

Table 8: Pair Wise Comparisons of Main Criteria

A. Imp.	F. Imp.	F. Imp.	W. Imp.	Criteria	Eq. Imp.	Criteria	W. Imp.	F. Imp.	F. Imp.	A. Imp.
(9)	(7)	(5)	(3)		(1)		(3)	(5)	(7)	(9)
				RGC	✓	SC				
		✓		RGC		PC				
				RGC		TRF	✓			
				SC		PC	✓			
				SC		TRF			✓	
				PC		TRF			✓	

	RGC	SC	PC	TRF
RGC	1	1	1/5	3
SC	1	1	3	7
PC	5	1/3	1	7
TRF	1/3	1/7	1/7	1

Table 9: Comparison matrices for main criteria

Table10: Pair Wise Comparisons of **Road Geometric Characteristics** with Alternatives

A. Imp.	F. Imp.	F. Imp.	W. Imp.	Criteria	Eq. Imp.	Criteria	W. Imp.	F. Imp.	F. Imp.	A. Imp.
(9)	(7)	(5)	(3)		(1)		(3)	(5)	(7)	(9)
				SD	✓	SC				
				SD		SE		✓		
		✓		SD		SRE				
				SD		DP				✓
				SC		SE				✓
				SC		SRE			✓	
				SC		DP		✓		
				SE		SRE	✓			
				SE		DP	✓			
		✓		SRE		DP				

Table11: Comparison matrices for main criteria with Road Geometric Characteristics

Road Geometric Characteristics	SD	SC	SE	SRE	DP
SD	1	1	5	1/5	9
SC	1	1	9	7	5
SE	1/5	1/9	1	3	3
SRE	5	1/7	1/3	1	1/5
DP	1/9	1/5	1/3	5	1

Table 12: Pair Wise Comparisons of **Shoulder Characteristics** with Alternatives Area

A. Imp.	F. Imp.	F. Imp.	W. Imp.	Criteria	Eq. Imp.	Criteria	W. Imp.	F. Imp.	F. Imp.	A. Imp.
(9)	(7)	(5)	(3)		(1)		(3)	(5)	(7)	(9)
				SW		SD	✓			
		✓		SW		QS				
				SW	✓	PEF				
				SD		QS	✓			
				SD		PEF		✓		
				QS		PEF		✓		

Table 13: Comparison matrices for main criteria with **Shoulder Characteristics**

Shoulder Characteristics	SW	SD	QS	PEF
SW	1	3	1/5	1
SD	1/3	1	3	5
QS	5	1/3	1	5
PEF	1	1/5	1/5	1

Table 14: Pair Wise Comparisons of **Pavement Condition** with Alternatives Area

A. Imp.	F. Imp.	F. Imp.	W. Imp.	Criteria	Eq. Imp.	Criteria	W. Imp.	F. Imp.	F. Imp.	A. Imp.
(9)	(7)	(5)	(3)		(1)		(3)	(5)	(7)	(9)
				PH	✓	R&S				
				PH		CR	✓			
				PH		RUT		✓		
		✓		R&S		CR				
				R&S		RUT	✓			
				CR		RUT	✓			

Table 15: Comparison matrices for main criteria with **Pavement Condition**

Pavement Condition	PH	R&S	CR	RUT
PH	1	1	3	5
R&S	1	1	1/5	3
CR	1/3	5	1	3
RUT	1/5	1/3	1/3	1

Table16: Pair Wise Comparisons of Traffic with Alternatives Area

A. Imp.	F. Imp.	F. Imp.	W. Imp.	Criteria	Eq. Imp.	Criteria	W. Imp.	F. Imp.	F. Imp.	A. Imp.
(9)	(7)	(5)	(3)		(1)		(3)	(5)	(7)	(9)
				DHR	✓	BT				
				DHR	✓	S&M				
				DHR		DE	✓			
				BT		S&M		✓		
		✓		BT		DE				
			✓	S&M		DE				

Table 17: Comparison matrices for main criteria with Traffic

Traffic	DHR	BT	S&M	DE
DHR	1	1	1	3
BT	1	1	5	1/5
S&M	1	1/5	1	1/3
DE	1/3	5	3	1

Table 18: Aggregated results for each alternative according to each criterion

Criteria.	RGC	SD	PVC	TRF	PRIORITY
Weightage. (%)	23%	43%	30%	5%	
SD	42 %				1
SC	34 %				2
SE	8 %				14
SRE	10 %				13
DP	5 %				15
SW		28 %			7
SD		19 %			12
QS		24 %			9
PEF		30%			5
PH			29%		6
R&S			25 %		17
CR			21 %		11
RUT			25 %		8
DHR				33 %	3
BT				31 %	4
S&M				14 %	16
DE				22 %	10

IV: RESULTS AND DISCUSSION

Table 19: Weights of Factors by Four Major Criteria

Criteria	Alternative	Weight (%)
Road Geometric Characteristic	Sight distance	42
Road Geometric Characteristic	Sharp curve	34
Traffic	Direct Access from house	33
Traffic	Blind turn	31
Shoulder characteristic	Pavement edge failure	30
Pavement condition	Pothole	29
Shoulder characteristic	Shoulder width	28
Pavement condition	Rutting	25
Shoulder characteristic	Quality of shoulder	24
Traffic	Delineation	22
Pavement condition	Cracking	21
Shoulder characteristic	Shoulder drop	19
Road Geometric Characteristic	Severity of road side environment	14
Road Geometric Characteristic	Super elevation	14
Road Geometric Characteristic	Drainage provision	10
Traffic	Sign and marking	8
Pavement condition	Reveling and spelling	5

Depending on this result, **Alternative 1 (Sight distance)** has the largest total score. Therefore, it is suggested as the very important factor among other of them to Decides safety impact factors that affect safety assessment of PMGSY road from project managers point view in Nashik city, with respect to 4 main criteria and the AHP model preferences of decision makers. **Alternative 2(Sharp curve)** has the second largest total score, **Alternative 14** has the third largest total score, **Alternative 15** has the fourth largest total score **Alternative 9** has the fifth largest total score **Alternative 6** has the sixth largest total score **Alternative 4** has the seventh largest total score **Alternative 6** has the eighth largest total score **Alternative 8** has the ninth largest total score **Alternative 17** has the tenth largest total score. This are the 10 most important factor which is mostly responsible for road safety as per road engineer's point of view. This Ten factor is same as the factor which is obtained from RII method.

According to result we can also find how many times one alternative is preferred by experts than another alternative.

- Alternative 1 is preferred by experts 1.23times than alternative 2 eg. (42/34)

- Alternative 1 is preferred by experts 1.27 times than alternative 14
- Alternative 1 is preferred by experts 1.35 times than alternative 15
- Alternative 1 is preferred by experts 1.40 times than alternative 9
- Alternative 1 is preferred by experts 1.44 times than alternative 10
- Alternative 1 is preferred by experts 1.5 times than alternative 6
- Alternative 1 is preferred by experts 1.68 times than alternative 13
- Alternative 1 is preferred by experts 1.75 times than alternative 8
- Alternative 1 is preferred by experts 1.90 times than alternative 17
- Alternative 1 is preferred by experts 2.00 times than alternative 12
- Alternative 1 is preferred by experts 2.20 times than alternative 7
- Alternative 1 is preferred by experts 3.00 times than alternative 4
- Alternative 1 is preferred by experts 3.00 times than alternative 3
- Alternative 1 is preferred by experts 4.20 times than alternative 5
- Alternative 1 is preferred by experts 5.2 times than alternative 16
- Alternative 1 is preferred by experts 8.4 times than alternative 11

V: CONCLUSION

In this research paper it is concluded that the developed Analytic hierarchy process (AHP) expert model works adequately and gives acceptable results as well as shows accurate decisions in safety impact factor selection for a PMGSY road . An example of safety factor selection was created to decide AHP application in most of Rural road projects .It was made clear from the output of each project managers for each of the safety factor, that most of the area of the AHP priority stack is occupied by Road geometric characteristic and pavement condition criteria's, thus, showing the desired dominance of these two criteria in the selection process. And this study is applied on the selected case study and to check the accidents rates is increases due to this factors.

According to Analysis it is observed that the Alterative, Sight distance, sharp curve, Direct Access from house to road, Blind Turn, Shoulder width, Rutting, Pavement Edge Failure. This are very important factor as safety point of view which is obtained by RII and AHP met

Now this study is implement for this four road which is selected for case study to check that measurement of this road is provided as per criteria or not. And then to check how this factors are effect on accidents rate.
For case study four rural road has select. All measurement had taken according to IRC guidelines.

1. According to Accidents record from 2013 to 2017 approximately 15 accidents were happened due to **Sight distance** is not provided as per IRC. According to IRC sight distance for rural road is above 90 Meter. But sight distance is actually provided at selected road is for **Road 1: < 90M, Road 2: <90M, Road 3: <90M, which is poor as per IRC and for Road 4: =90 which is medium.** According to IRC guidelines the sight distance is not provided properly so the accidents rates is increase.
2. According to Accidents record from 2013 to 2017 approximately 11 accidents were happened due to **Sharp Curve** is not provided as per IRC. According to IRC Sharp Curve for rural road is above 90°. But Sharp Curve is actually provided at selected road is for **Road 1: <90°, Road 2: <90°, which is poor as per IRC and for Road 3: =90°, Road 4: =90° which is medium.** According to IRC guidelines the Sharp Curve is not provided properly so the accidents rates is increase.
3. According to Accidents record from 2013 to 2017 approximately 15 accidents were happened due to **Severity of roadside environment** is not provided as per IRC. According to IRC Severity of roadside environment for rural road is below 90M. But Severity of roadside environment is actually provided at selected road is for **Road 1: >100M, Road 2: >100M, is Road 3: >100M, Road 4: >100M which is poor.** According to IRC guidelines the Severity of roadside environment is not provided properly so the accidents rates is increase.
4. According to Accidents record from 2013 to 2017 approximately 8 accidents were happened due to **Shoulder Width** is not provided as per IRC. According to IRC Shoulder Width for rural road is 1.875 or greater than 1.875. But Shoulder Width is actually provided at selected road is for **Road 1: 0.5-0.7M, Road 2: 0.5-0.6M, is Road 3: 1-1.2M, Road 4: 1.3-1.6M which is poor.** According to IRC guidelines the Shoulder Width is not provided properly so the accidents rates is increase.
5. According to Accidents record from 2013 to 2017 approximately 13 accidents were happened due to **Pavement Edge Failure** is not provided as per IRC. According to IRC Pavement Edge Failure for rural road is <1%. But Pavement Edge Failure is actually provided at selected road is for **Road 1: 1.2%, Road 2: >2%, is Road 3: 1.2%, Road 4:** <1% **which is poor.** According to IRC guidelines the Pavement Edge Failure is not provided properly so the accidents rates is increase.
6. According to Accidents record from 2013 to 2017 approximately 9 accidents were happened due to **Cracking** is not provided as per IRC. According to IRC Cracking for rural road is <0.635CM. But cracking is actually at selected road is for **Road 1: 0.5-1CM, Road 2: 0.5-1CM, is Road 3: 1-1.5 CM, Road 4: 1-1.5 CM which is poor.** According to IRC guidelines the Cracking is increases so the accidents rates is increase.
7. According to Accidents record from 2013 to 2017 approximately 19 accidents were happened due to **direct access from houses to roads** is Maximum. According to IRC Direct access from houses to roads for rural road is minimum, 1-3 no of houses. But Direct access from houses to roads is actually at selected road is for **Road 1: 7 no, Road 2: 14 no, is Road 3: 23 no, Road 4: 9 no which is poor.** According to IRC guidelines the direct access from houses to roads is increases so the accidents rates is increase.
8. According to Accidents record from 2013 to 2017 approximately 20 accidents were happened due to **blind turn on road** is Maximum. According to IRC Blind turn for rural road is minimum. Blind turn on road is actually at selected road is for **Road 1: 6**

no, Road 2: 4 no, is Road 3: 9 no, Road 4: 11 no which is poor. According to IRC guidelines the Blind turn on road is increases so the accidents rates is increase

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